TYPES OF WELLS; THEIR COMPARATIVE COST AND MERITS AND METHODS OF PROTECTION FROM POLLUTION.

(Continued from last week.)

Safety Distance.—By "safety distance" is meant the distance from a source of pollution at which a well may be of a "cone of safety," by which is meant an inverted conical sunk with a degree of safety. Some writers have spoken section of earth, with its apex at the bottom of the well and its base a circle of some fixed radius on the surface. The radius taken by some is the depth of the well, by others twice the depth of the well, but such limits are usually fixed without taking into consideration the nature of ground-water movements or the character of the passages in which it moves. The distance of safety also depends to a considerable degree on the quantity and concentration of the pollution entering the ground water. Where coming from the surface the amount is commonly not large, but where entering at a considerable depth, as from cesspools sunk in limestone or in porous sands, which also supply water to wells, it may reach the water stratum almost undiluted. It follows that no absolute radius can be laid down, each case demanding individual consideration. Certain generalizations, however, may be made as to conditions in materials of different types and under different topographic conditions, some of which are indicated below.

Clay and Till.—In ordinary clay and in the pebbly or boulder clay known as "till" the water circulates in part by general seepage through the mass, in part through relatively thin, sandy layers, and in part along more or less open but irregular tubular passages. Seepage through the body of the clay or till is very slow, and polluting matter is rarely carried for any great lateral distance; 100 feet from the

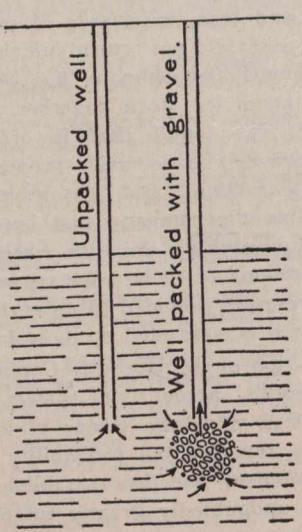

Fig. 3—Diagram Showing Advantages of Packing with Sand and Gravel.

nearest source of pollution may, perhaps, be regarded as a safe limit. The clay offers even more resistance to the passage of water directly downward, a 5-foot bed as a rule effectively shutting off polluting matter from the underlying water beds, unless such matter obtains access along the break made in sinking a well or other excavation. When the water follows sandy layers the movement, though much faster than in uniform clay, is nevertheless, not very rapid, rarely exceeding a few feet per day, and pollution does not often extend much over 150 feet, 200 feet usually being a safe distance. In open passages movement is much more rapid, and may amount to several hundred feet a day in extreme cases. Under such conditions there is no purification and relatively little dilution, and if the passage discharges into a well dangerous contamination may result. In a thickly inhabited region a well depending for its supply on passages of this nature is never safe.

Sand.—A bed of sand is among the safer water beds. Being of an incoherent nature, the material rarely contains open passages, the water circulating in general by a slow movement among the grains. The rate, though sometimes amounting to 50 feet or more a day, is usually under 5 feet, and may be under 1 foot. A well 200 feet from the nearest point of pollution is probably safe in fine and medium sands, but in coarse sands and gravel a much greater distance may be essential.

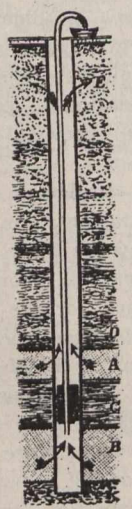

Fig. 4—Section of Well Showing Loss by Leakage into the Superficial Deposits.

Sandstone.—The movement of water in sandstone is in part through the body of the rock and in part through small open passages along the joint or bedding planes. Owing to the greater density of the rock resulting from the cementation of the grains the distance to which pollution may extend through the pores of the rock is less than in sand, 100 feet usually being a safe distance. Probably even with the water moving along the joints and bedding planes, 125 to 150 feet from the source of pollution is a safe distance for a well.

Slate and Shale.—In slate and shale the water follows in part the planes of stratification or bedding, and in part the more or less vertical joints by which these rocks are usually cut. Unless certain of the layers are sandy the movement along the bedding planes is generally slow, and pollution is carried for only short distances. The joints, however, are in many places fairly open, and may conduct the water within a short time to considerable distances, possibly many hundred feet, like the granite joints described elsewhere. However, unless the examination of the rock or the behavior of the drill in the well shows the presence of such open joints, a well in slate or shale may usually be considered safe if not less than 100 feet from a source of pollution.

Limestone.—The movement of water through limestone is almost entirely by means of open passages. Some of these are only a minute fraction of an inch in width, being no wider than joint and bedding planes. In such passages the movement of water is very slow and pollution is rarely carried far, 150 feet from a possible source usually being a safe distance. Other passages, however, are of considerable size, perhaps many feet in diameter, and may extend for miles. One chamber in Mammoth Cave is nearly ten miles long, and there is evidence that similar, though perhaps smaller, channels exist at numerous other points. These openings are not uncommonly occupied by flowing streams which, if polluting matter is introduced, may carry it for many miles. Such